



## **BLACK MOUNTAIN CONSULTING LLC**

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March 19, 2019

Black Mountain Project No. 180178-GEO

### **Lewis County Radio**

#### **c/o Cushing Civil Engineers**

107 SE Washington Street, Suite 265

Portland, Oregon 97214

Attn: Mr. Kenny McManaway

Subject: Geotechnical Engineering Evaluation

Chehalis Ridge Radio

Off NE Jefferson Avenue

Chehalis, Washington 98532

Black Mountain Consulting LLC (Black Mountain) is pleased to submit this report describing our recent geotechnical engineering evaluation for the Chehalis Ridge Radio tower site. The purpose of our work was to interpret general surface and subsurface site conditions in order to provide recommendations for design and construction. Our scope of services was authorized by Cushing Civil Engineers (CCE) and consisted of a surface reconnaissance, a subsurface exploration, geotechnical analyses, and report preparation.

We prepared this report in accordance with generally accepted geotechnical engineering practices at the time we prepared it, for the exclusive use of CCE and their agents, for specific application to this project. Use or reliance upon this report by a third party is at their own risk. Black Mountain does not make any representation or warranty, express or implied, to such other parties as to the accuracy or completeness of this report or the suitability of its use by such other parties for any purpose whatever, known or unknown, to Black Mountain.

### **Black Mountain Consulting LLC**

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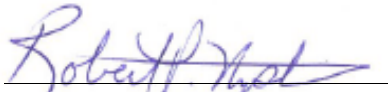
**503.625.2517**

**[www.blkmountain.com](http://www.blkmountain.com)**

We appreciate the opportunity to be of service to you. If you have any questions, or if we can be of further assistance to you, please contact us at (503) 625.2517.

Respectfully Submitted,

**Black Mountain Consulting LLC**



Robert Nystrom, L.G.  
Staff Geologist



EXPIRES 12-31-2019

Jeanne M. Niemer; PE  
Principal Geotechnical Engineer

- |              |   |
|--------------|---|
| Attachment A | Figures<br>Figure 1 - Site Location Map<br>Figure 2 - Site & Exploration Plan |
| Attachment B | Subsurface Exploration Log  |

**Cushing Civil Engineers  
Geotechnical Engineering Evaluation**

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**Chehalis Ridge Radio  
Chehalis, Washington**

**180178-GEO  
March 2019**

## PROJECT DESCRIPTION

The proposed project will consist of constructing a new 80' tall self-support telecommunications tower and installing ground equipment within a new equipment shelter and compound. Additionally, a new gravel access road will be constructed from an existing access road to the site. The property is located near NE Jefferson Avenue (Parcel 004696000000), in Chehalis, Lewis County, Washington, as shown on the attached *Site Location Map*, Figure 1.

## SITE CONDITIONS

### ***Regional Geology***

The geology of the area consists of a complex group of terrace deposits, marine and sedimentary rocks, and alluvial sedimentary deposits. The proposed lease area is located on a unit of Pleistocene terrace deposits (Qt) that is composed of unconsolidated to partially consolidated fluvial and glaciofluvial sand and gravel lacustrine with lesser amounts of silt and clay (Roberts, A.E., 1958, *Geology and Coal Resources of the Toledo-Castle Rock District, Cowlitz and Lewis Counties, Washington*: U. S. Geological Survey Bulletin 1062). A unit of Upper Eocene non-marine and marine rocks (E1) is located adjacent to the Pleistocene terrace deposits. These middle Eocene rocks consist of sandstone and basalt with some siltstone, shale and coal beds (<https://mrdata.usgs.gov/geology/state/sgmc-unit.php?unit=WAE01;0>). Other units in the region include Oligocene marine rocks, including basaltic sandstone, and Holocene age alluvium deposits (Qa) consisting of silt, sand, gravel, and glacial deposits (Hunting, M.T., Bennett, W.A.G., Livingston, V.E.Jr., and Moen, W.S., 1961, *Geologic Map of Washington*) fill in low-lying streambeds in this area.

### ***Surface Conditions***

The proposed lease area is located near the top of a northwest-southeast trending ridge and is covered with trees. The lease area and immediate surrounding area slope down gently to the south-southeast and there was no standing water present at the time of our site visit.

### ***Subsurface Conditions***

We explored the subsurface conditions at the project site on March 13, 2019. Our subsurface exploration consisted of advancing one boring (designated B-1) near the planned tower site (not staked) as shown on the attached *Site & Exploration Plan*, Figure 2. We logged and classified the subsurface materials in general accordance with the Manual Visual Classification Method (ASTM D 2488).

We encountered approximately 5 feet of stiff silt and loose sand overlying dense to very dense silty fine sand to the full depth of our exploration at 32 feet below ground surface (bgs). We interpret the very dense to be severely weathered sandstone.

We did not encounter groundwater in the boring at the time of our exploration. Groundwater levels may fluctuate in response to changing precipitation patterns, off-site construction activities, and changes in site utilization.

## SEISMIC HAZARD STUDY

We evaluated seismic hazards in accordance based on our site explorations, analyses, experience in the vicinity of the site, and a review of available literature.

### ***Seismic Sources***

There are three primary earthquake sources for this site: Cascadia Subduction Zone (CSZ) intraplate and interface earthquakes, and local crustal earthquakes that could occur in the North American Plate. CSZ intraplate earthquakes that could occur within the subducted Juan de Fuca plate are anticipated to have magnitudes on the order of 7.0 to 7.5, at a depth of about 40 to 60 km. This subduction is occurring beneath the North American Plate in the coastal regions between Vancouver Island and northern California. The fault trace is mapped approximately 50 to 120 km off the Oregon Coast. They present a low-moderate hazard.

An interface event earthquake on the seismogenic portion of the interface between the Juan de Fuca Plate and the North American Plate is capable of generating earthquakes with a moment magnitude of between 8.5 and 9.0. A magnitude 8.5 is expected to correspond to an average 10 percent of being exceeded in 50 years, and a magnitude 9.0 corresponds to an average 2 percent of being exceeded in 50 years.

Local crustal earthquakes may occur from east-west and northwest-southeast trending faults in the region. The nearest known fault is an unnamed fault located approximately 2.2 km north of the site. This fault, as well as other nearby faults in the region, is not yet characterized.

### ***Site Specific Ground Motions***

Our experience with ground motion modeling indicates that the site subsurface conditions are not susceptible to amplification beyond code spectra. We recommend that the code spectra for Class D given in the Recommendations section be used for design of the tower.

### ***Liquefaction, Fault Rupture, Slope Stability and Tsunami Inundation***

The site soils below about five feet consist of dense to very dense sand/weathered sandstone. We did not encounter groundwater during our exploration and these soil types are not susceptible to settlement from liquefaction during a design level earthquake.

No faults are mapped on the site; therefore the hazard from fault rupture is low.

The site is located inland, outside of tsunami inundation areas.

The site slopes are gentle, and therefore the site is not susceptible to earthquake induced slope instability.

## **CONCLUSIONS**

Based on the results of our explorations and analyses, the tower can be supported on a mat foundation that derives its support from the dense silty fine sand that we encountered below about 5 feet. The equipment shelter can be constructed on the upper stiff silt or on compacted structural fill.

The following sections present our recommendations for design and construction of the foundation for the tower.

**Seismic Conditions**

Based on our analysis of subsurface exploration logs and a review of published geologic maps, we interpret the on-site soil conditions to correspond to Site Class D, as defined by Table 1613.5.2 of the 2012 *International Building Code*.

Based on the consistency of the site soils and the lack of groundwater, the potential for liquefaction settlement during a design level earthquake is negligible.

Our specific recommendations are presented in the following sections.

**GEOTECHNICAL DESIGN RECOMMENDATIONS****Seismic Design Parameters**

Our recommended seismic design parameters are summarized in the table below.

Seismic Design Parameters		
	Short Period	1 Second
Mapped Spectral Acceleration Values	$S_S=1.154$	$S_1=0.501$
Site Class	D	
Site Coefficient	$F_a=1.038$	$F_v=1.5$
Design Spectral Response Acceleration Parameters	$S_{DS}=0.799$	$S_{D1}=0.501$

**Mat Foundation**

A mat foundation may be used to support the tower at this site. The base of the mat foundation should be founded at a minimum depth of five feet bgs, on the dense silty fine sand. After excavation to design grade, the subgrade should be cleaned of material loosened by excavation. Irregularities resulting from the excavation should be filled with sand, lean concrete, or other suitable material to produce a level bearing surface for the foundation.

We recommend using an ultimate static bearing capacity of 10,000 pounds per square foot (psf). In accordance with the provisions of the EIA/TIA 222-G code, this static bearing pressure does not incorporate a factor of safety. We estimate post construction settlements will be less than one inch. We estimate that the differential settlement will be approximately half of the total settlement.

Lateral loads acting on the foundations can be resisted by passive earth pressure on one side of the foundation and by friction along the soil-concrete interface at the base of the foundation. We recommend using an ultimate foundation base friction coefficient of 0.70 for the sand. A passive earth pressure of 700 pounds per-cubic-foot (pcf), expressed as an equivalent fluid unit weight, may be used for that portion of the foundation embedded more than one foot below finished exterior subgrade elevation. These lateral resistance values do not incorporate a safety factor, in accordance with the provisions of the EIA/TIA 222-G code. In order to develop these capacities, concrete must be poured neat in excavations, the adjacent grade must be level, and the static ground water level must remain below the base of the footing throughout the year. The passive pressure within the upper foot of embedment should be neglected.

Eccentric loads and moments acting on the foundation produce a skewed bearing pressure distribution to the ground. The mat foundation should be sized so that the resultant load acts within the middle third of the foundation for one-way and two-way eccentric loading to maintain a compressive contact pressure along the base of the foundation. The maximum bearing pressure from the eccentric loading must be less than the allowable bearing pressure.

Uplift loads can be resisted by the self-weight of the mat and the backfill directly overlying the embedded mat foundation. The overlying sand can be re-used as backfill over the mat provided it is prepared and placed in accordance with recommendations contained in the Structural Fill section of this report. For preliminary design purposes, the total unit weight of the overlying soils can be assumed to be 100 pounds pcf.

Excavations should be made in accordance with applicable Occupational Safety and Health Administration (OSHA) and state regulations. It is the contractor's responsibility to select the excavation and dewatering methods, to monitor the excavations for safety and to provide any shoring required to protect personnel and adjacent improvements.

### ***Spread Footings***

Lightly loaded structures such as the equipment shelter can be supported on spread footings. Continuous-wall and isolated-spread footings should be at least 18 and 24 inches wide, respectively. For frost protection, the footings should be founded at least 24 inches below the lowest adjacent grades or deeper if required by local building code.

Footings should bear directly on the stiff silt that we encountered near the ground surface or on structural fill placed in accordance with our recommendations. Footings bearing on the silt or structural fill should be sized for an allowable bearing capacity of 2,000 psf. We estimate post construction settlements will be less than one inch for the above recommended bearing capacity. We estimate that the differential settlement will be approximately half of the total settlement. Our recommended bearing capacity is based on limiting settlements and includes a factor of safety of 3 against bearing capacity failure.

Lateral loads acting on the foundations can be resisted by passive earth pressures on the sides of the foundation and by friction along the soil-concrete interface at the base of the foundation. We recommend using an allowable passive earth pressure of 250 pounds per cubic foot (pcf) for foundations confined by the silt or structural fill placed in accordance with our recommendations. The passive pressure within the upper two feet of embedment should be neglected. We recommend an allowable coefficient of friction of 0.32. In order to develop these capacities, concrete must be poured neat in excavations, the adjacent grade must be level, and the static ground water level must remain below the base of the footing throughout the year. These allowable lateral resistance values include a minimal factor of safety of 1.5.

### ***Floor Slabs***

We recommend a 6-inch-thick layer of imported granular structural fill be placed and compacted over the prepared subgrade. The granular fill should be placed in 6-inch-thick lifts and compacted to at least 95 percent of the maximum dry density, as determined by the American Society for Testing and Materials (ASTM) D 1557. A modulus of subgrade reaction value of 100 pounds per cubic inch (pci) may be used to design the floor slab.

## ***Foundation Construction Considerations***

A geotechnical engineer from Black Mountain (or their representative) should confirm suitable bearing conditions and evaluate the foundation subgrades. Observations should also confirm that loose or soft material, organics, unsuitable fill, or old topsoil zones were removed. Localized deepening of footing excavations may be required to penetrate any deleterious materials.

Because foundation stresses are transferred outward as well as downward into the bearing soils, all footing over-excavations should extend horizontally outward from the footing edge a distance equal to one half the over-excavation depth for the structural backfill.

## ***Access Driveway***

We recommend that the subgrade for any access roadway be prepared in accordance with the Site Preparation section of this report. For planning purposes, we anticipate that 12-18 inches of gravel base rock on the order of 3-inch minus material and a minimum 3-inches of ¾-inch minus rock surfacing will be required to create a stable gravel roadway surface at this site. We recommend providing a geotextile between the baserock and the subgrade to prevent migration of fines into base rock. Black Mountain can provide additional subgrade stabilization or gravel road section recommendations based on observed field conditions at the time of construction.

## **CONSTRUCTION RECOMMENDATIONS**

### ***Site Preparation***

*Clearing and Stripping:* After surface and near-surface water sources have been controlled, the construction areas should be cleared and stripped of organic matter and other deleterious materials. Silt fences, hay bales, buffer zones of natural growth, sedimentation ponds, and granular haul roads should be used as required to reduce sediment transport during construction to acceptable levels.

Where present, fill and existing topsoil should be stripped and removed from proposed development locations and for a five-foot-margin around such areas. Based on our explorations, we anticipate the depth of stripping will be negligible, although greater stripping depths may be required if deleterious materials are encountered. Deleterious materials encountered during site preparation should be removed from the subgrade soils and hauled off site for disposal. Stripped material should be transported off site for disposal or stockpiled for use in landscaped areas. If stripping operations occur during wet weather, a generally greater stripping depth might be required in order to remove disturbed moisture-sensitive soils; therefore, stripping is best performed during a period of dry weather.

*Excavations:* We anticipate that site grading will be minimal. Where required, temporary soil cuts associated with site excavations or regrading activities should be adequately sloped back to prevent sloughing and collapse, unless a shoring box or other suitable excavation side wall bracing is provided. It is the responsibility of the contractor to ensure that excavations are properly sloped or braced for worker safety protection, in accordance with OSHA safety guidelines.

*Final Grades:* Final site grades should slope downward away from the structure at a minimum of two percent and runoff should be conveyed to a suitable drainage outlet. Additionally, the area surrounding the structure could be capped with concrete, asphalt or compacted, low-permeability soils to reduce surface water infiltration into the subsurface soils near the foundation.



### **Structural Fill**

The following recommendations for structural fill are provided for design and construction purposes, if required.

*Materials:* Structural fill includes any fill materials placed under footings, pavements, or driveways and backfill over the embedded mat foundation. Typical materials used for structural fill include: clean, well-graded sand and gravel; clean sand; crushed rock; controlled-density fill (CDF); lean-mix concrete; and various soil mixtures of silt, sand, and gravel. Recycled concrete, asphalt, and glass derived from pulverized parent materials may also be used as structural fill when mixed at a ratio of 1:1 with clean gravel. Use of the on-site soils as structural fill is also feasible.

*Placement and Compaction:* When used as structural fill, the on-site soils should be placed in lifts with a maximum thickness of 8 inches and compacted to not less than 92 percent of the material's maximum dry density, as determined by ASTM D-1557. The on-site soils should be moisture-conditioned to within 3 percent of the optimum moisture content (ASTM D-1557). If the on-site soils cannot be properly moisture-conditioned, we recommend using imported granular material for structural fill.

Imported granular structural fill should consist of angular pit or quarry run rock, crushed rock, or crushed gravel and sand that is fairly well graded between coarse and fine particle sizes. The fill should contain no organic matter or other deleterious materials, have a maximum particle size of one inch, and have less than 5 percent passing the U.S. No. 200 Sieve. In deep excavations, or where subgrade soils require stabilization, the particle size may be increased to four inches. The percentage of fines can be increased to 12 percent of the material passing the U.S. No. 200 Sieve if placed during dry weather and provided the fill material is moisture-conditioned, as necessary, for proper compaction. The material should be placed in lifts with a maximum uncompacted thickness of 12 inches and be compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D-1557. During the wet season or when wet subgrade conditions exist, the initial lift thickness should be increased to 24 inches and should be compacted by rolling with a smooth-drum, nonvibratory roller.

CDF and lean-mix concrete do not require special placement or compaction procedures. Regardless of location or material, all structural fill should be placed over firm, unyielding subgrade soils. If earthwork takes place during freezing conditions, we recommend that all exposed subgrades be allowed to thaw and be recompacted prior to placing subsequent lifts of structural fill.

### **CONSTRUCTION OBSERVATIONS**

Satisfactory earthwork performance depends on the quality of construction. Sufficient monitoring of the contractor's activities is a key part ensuring that work is completed in accordance with the construction drawings and specifications. We recommend that a representative from Black Mountain observe that the subsurface conditions observed during our site investigation are consistent with those encountered during construction, and that foundation subgrades are suitable for placement of structural fill, rebar, or concrete for the new structures.

*Some jurisdictions require a final letter of geotechnical compliance before they will finalize a permit. It is incumbent on the client to determine if a final letter of geotechnical compliance is required by the jurisdiction. If such a letter is required, a representative from Black Mountain MUST observe pier installation and/or foundation subgrades PRIOR to concrete being poured for the foundation. If Black*

*Mountain does not perform this observation, we cannot provide a final letter of geotechnical compliance, and a permit will not be eligible for final sign-off. It is the owner's responsibility to ensure that Black Mountain be notified in a timely manner (i.e., at least 48 hours prior to the required site observation) of the need for our services on site during construction.*

### CLOSURE

We have prepared this report for use by the owner/developer and other members of the design and construction team for the proposed tower site. The opinions and recommendations contained within this report are not intended to be, nor should they be, construed as a warranty of subsurface conditions, but are forwarded to assist in the planning and design process.

We have made observations based on our explorations that indicate the soil conditions at only those specific locations and only to the depths penetrated. These observations do not necessarily reflect soil types, strata thickness, or water level variations that may exist in other locations. If subsurface conditions vary from those encountered in our site exploration, Black Mountain should be alerted to the change in conditions so that we may provide additional geotechnical recommendations, if necessary. The future performance and integrity of the improvements will depend largely on proper initial site preparation, drainage, and construction procedures. Observation by experienced geotechnical personnel should be considered an integral part of the construction process.

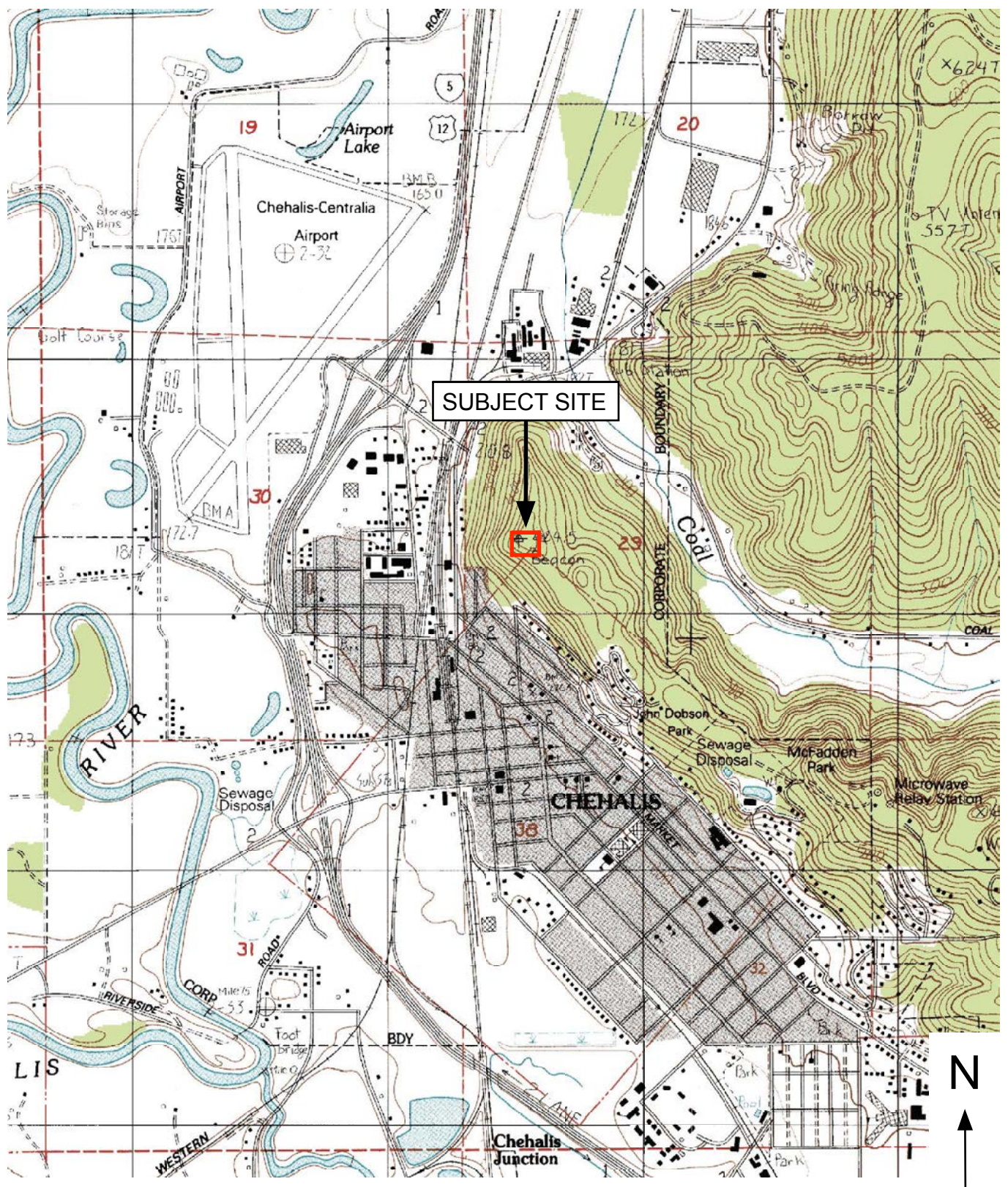
The conclusions and recommendations contained in this report are based on our understanding of the currently proposed project, as derived from written and verbal information supplied to us by the client. When the design has been finalized, we recommend that the design and specifications our firm review it to see that our recommendations have been interpreted and implemented as intended. If design changes are made, we request that we be retained to review our conclusions and recommendations and to provide a written modification or verification.

The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in our report for consideration in design. Within the limitations of scope, schedule, and budget, our services have been executed in accordance with the generally accepted practices in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

**ATTACHMENT A**

**FIGURES**





Base Map Courtesy of U.S.G.S. Topographic Map "Centralia, Wash." (1985) Scale Not to Scale

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**FIGURE 1 - Location/Topographic Map**

**Project :** 180178-GEO

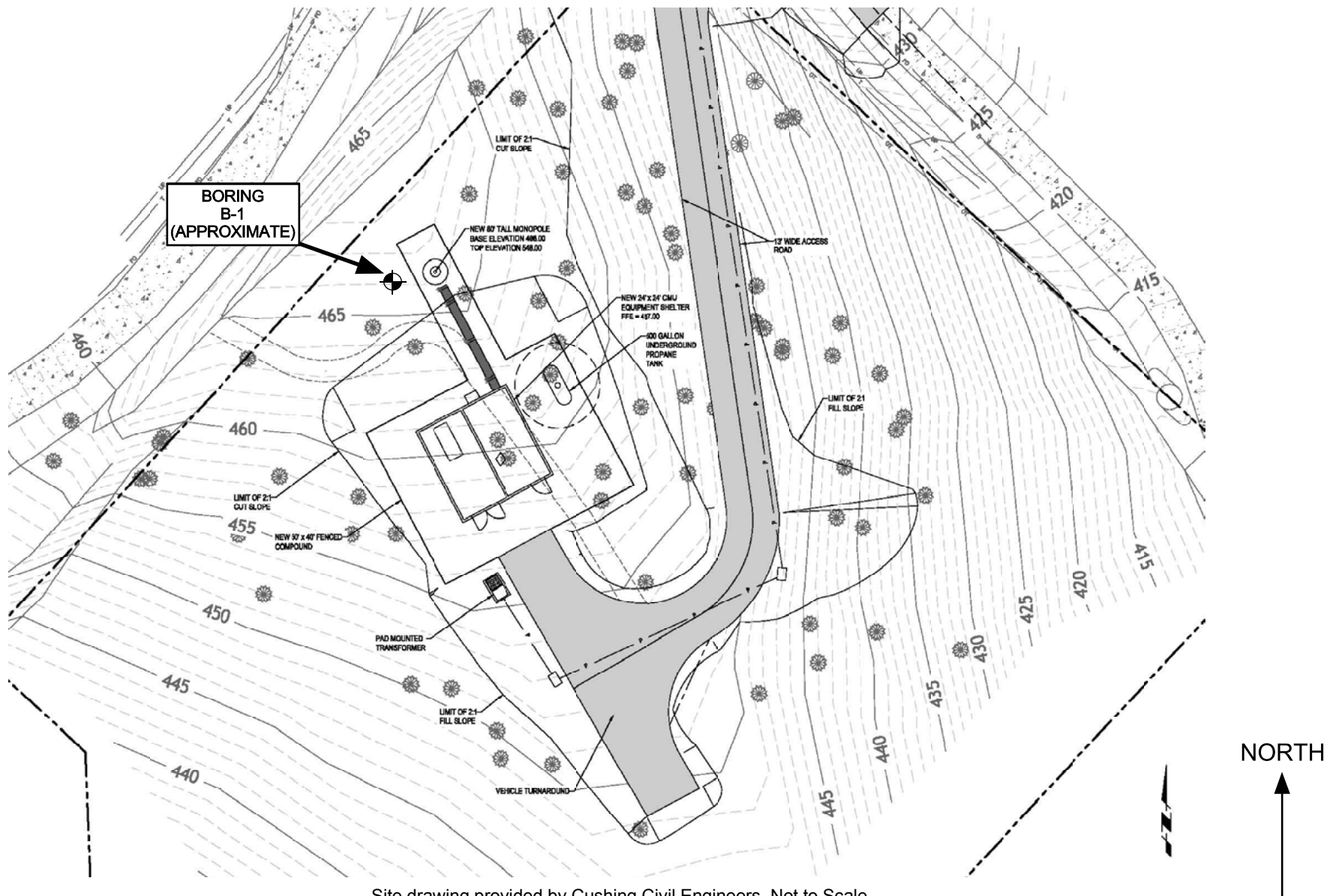
**Client :** Lewis County c/o CCE

**Location**

Chehalis Ridge Radio  
 Off NE Jefferson Avenue  
 Chehalis, Washington 98532

**Date :** March 2019





Site drawing provided by Cushing Civil Engineers, Not to Scale

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**FIGURE 2 - Site & Exploration Plan**

**Project :** 180178-PHI

**Client :** Lewis County c/o CCE

**Location**

Chehalis Ridge Radio  
Off NE Jefferson Avenue  
Chehalis, Washington 98532

**Date :** March 2019

**ATTACHMENT B**

**SUBSURFACE EXPLORATION LOG**

# BORING LOG












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Job Number: 180178-GEO

Boring No.: **B-1**

Elevation Reference : Ground Surface Elevation :		Well Completed : N.A. Casing Elevation : N.A.							OBSERVATIONS	TESTING
DEPTH (feet)		SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNT	POCKET PEN	TORVANE	GROUND WATER			
0	Stiff, brown, moist, SILT (ML) and CLAY (CL), some fine sand, duff		1	1 1 1	0.5				Slightly plastic	
	-----									
	Loose, yellow-oxidized, moist, silty fine SAND (SM) below 2.5'		2	4 4 6						
5	Becomes dense below 5'		3	12 17 27					Decrease in drilling speed below 4', possibly severley weathered sandstone below 4'. Color varies from light brown-oxidized to brown-oxidized with depth.	
			4	11 18 20						
10			5	16 24 25						
15	Becomes very dense below 15'		6	13 34 39					Further decrease in drilling speed below 13'. Water added periodically below 13'.	
20			7	13 34 39						
25			8	18 34 38						

LEGEND									
	2-inch O.D. Split-Spoon Sample		Static Water Level at Drilling		Grab Sample				
	1-inch Geoprobe		Static Water Level		Type of Analytical Testing Used				
	Sample not Recovered		Perched Groundwater		No Recovery				
			At Time of Drilling		At Time of Drilling				

Drilling Start Date: 3-13-19

Drilling Completion Date: 3-13-19

Logged By: RN

# BORING LOG

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PROJECT : Chehalis Ridge Radio  
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Job Number: 180178-GEO

Boring No.: **B-1**

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## LEGEND



2-inch O.D. Split-Spoon Sample

1" Geoprobe

Sample not Recovered



### Static Water Level at Drilling

### Static Water Level

### Perched Groundwater



Grab Sample

Type of Analytical Testing Used

No Recovery  
At Time of Drilling